Fully Coupled Hydro-Mechanical Modeling Of Hydraulic Fracturing In Barnett Shale Formation

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Abstract

The unconventional shale gas reservoirs have a major contribution to hydrocarbon production in recent years. The hydraulic stimulation technique is being used to enhance the productivity of the target reservoirs. The drilled wellbore and existing natural fractures in the host rocks have substantial impacts on the developed artificial fractures created during hydraulic fracturing. In this study, the novel investigations of the effect of wellbore azimuth in a reservoir including natural fractures were carried out using COMSOL Multiphysics®. The Barnett Shale formation in Texas, US was considered as the stimulated target reservoir. In COMSOL Multiphysics®, the Subsurface Flow Module was used to model the saturated porous media flow through Darcy's Law. The Fracture Flow interface was used to couple the physics of fractures with the surrounding matrix. Finally, the Transient Darcy's Law interface was combined with a linear elastic solid mechanics of the porous media matrix using the Poroelasticity interface. Two different scenarios of hydro-fractures development were modeled with the width/diameter of 35m and the length of 200m within a formation dimension of 200m×300m×60m as shown in Fig. 1. The interaction of hydro-fractures with natural fractures expanded the fluid flow network and stimulated the volumetric strain of the SRV as shown in pore pressure contours in Fig. 2. The novelty of this study was to show the poroelastic response of the shale rock formation with different hydro-fracture's orientation with respect to wellbore azimuth. The results showed that the tensile hydro-fractures initiated from the wellbore and oriented transversally (or longitudinally) where the wellbore azimuth was aligned with the maximum (or minimum) horizontal in-situ stress, respectively. The change in formation's primary porosity and the increase in pore pressure was investigated as the poroelastic response of the SRV. Finally, important parameters in hydraulic fracturing were evaluated and compared in each model such as the von Mises stress distribution and the change in the incremental water content of the formation during the operation.

Figures used in the abstract

Figure 1 : Computational domains including the compass rose with the azimuth of the maximum in-situ stress in blue and the natural fractures in red. a) scenario I, b) scenario II.

Figure 2 : The pore pressure contours after 8 hours of a) 165 MPa injection in scenario I, b) 78 MPa injection in scenario II.